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CENTRAL INTELLIGENCE AGENCY

INFORMATION REPORT

COUNTRY China/Manchuria

DATE DISTR. /5 Dec 53
25X1

SUBJECT Rare Metals Deposits

NO. OF PAGES 7
25X1

PLACE ACQUIRED

NO. OF ENCLS.
(LISTED BELOW)

DATE ACQUIRED

SUPPLEMENT TO
REPORT NO. 25X1

Date Info

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RARE METALS DEPOSITS IN CHINA1. INTRODUCTION

The occurrence of the rare metals deposits in China has been known but recently. During the period of Japanese occupation, Japanese geologists carried out a special program of investigations for U, Th, Zr, Ce, Be, Ta, Nb, Li, etc in North China and Manchuria where several valuable deposits were located.

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2. The scientific results on this subject have never been published in Japanese nor Chinese except as they occasionally appeared in scientific news. The Japanese official results, which were kept in a large research center in Manchuria, were unfortunately destroyed by fire in 1945 during the civil war. This report has been prepared with three objectives in mind, namely:

a. To summarize the results of the Chinese geologists' work prior to 1949 which are generally known to the public

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b. To restore the lost information

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c. To give a general clue to the metallogenetic provinces of rare metals deposits and predict the probable and possible areas bearing future prospects. The reserve of the newly discovered deposits has not yet been fully ascertained, but it is believed that considerable quantities must have already been found or will be found in the near future on account of the current cooperative activities undertaken in China.

3. According to the geological occurrence and geographical distribution four areas have been subdivided, namely: North Manchuria, South Manchuria, Suiyuan, and the Nanling Range. In addition several localities bearing possibilities have also been included, although their possible occurrence may require future investigation and confirmation.

4. The genesis of the rare metals deposits may be classified into three types:

- Placer deposits as those occur in the gold placer provinces of North Manchuria, the beach sands of Liaotung Peninsula, and the tin placer province of Kwangsi,
- Pegmatitic deposits of South Manchuria and Suiyuan provinces, and
- Hydrothermal deposits of the Nanling Range. Among them pegmatitic veins are the most widespread type and thus deserve special attention.

5. Most pegmatite-veins are banded or zoned and generally have ores concentrated as units. The distribution of metallic minerals in pegmatite-veins has no uniformity and thus the grade and size of the deposits are unpredictable. Most of the known pegmatites in China do not contain sufficient quantity of uranium-minerals to warrant mining for uranium alone, but considerable quantities may be recovered as by-products of mining for other non-radioactive rare metals.

6. The western coast of Liaotung Peninsula has one of the richest pegmatite-type deposits in the world, from which large quantities of radioactive and non-radioactive minerals may be mined at profit. There are four main lithological types of pegmatites containing abundant rare-metal minerals. Their mineral associations have been summarized in the following table.

Mineral Association	ROCK TYPES			
	Ordinary Pegmatite	Biotite-albite Pegmatite	Muscovite-albite Pegmatite	Lepidolite-K-feldspar Pegmatite
Monazite	*			
Allanite	**	*		
Zircon	*	(*)		
Betafite	*	**		
Samarskite	*	**		
Euxenite		**	(*)	
Fergusonite		**	*	
Beryl			**	*
Columbite			**	*
Lepidolite				**
Muscovite	(*)		**	
Biotite	(*)	*		
Tourmaline	*	(black)	(*)	** (green)
Garnet			*	*
Topaz				**
Fluorite				**
Characteristic Rare Metals	U, Th, Zr, Ce.		Be, Ta, Nb, Li.	

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THE PLACER DEPOSITS OF NORTH MANCHURIA

7. The gold-placers of North Manchuria provinces commonly contain considerable amounts of minerals of rare metals, such as monazite, zircon, tantalite, columbite, etc, mixed with black sands consisting of cassiterite, magnetite, ilmenite, garnet, etc, as the residual detrital minerals disintegrated from pre-Cambrian gneisses and granites.

8. The placers occurring in Hepei, Yilang district of Hokiang province (合江復市黑背) contain 6-7.3% zircon, 14-15% monazite as well as a small amount of tantalite, columbite and cassiterite etc. Those occurring in the Muling district of Sungkiang province (松江省穆棱縣) contain 8% zircon and 4.1% monazite. In Chungtakou, Mohar, Heilungkiang province (黑龍江省穆棱河中旦等) the placers contain 0.7-8.3% zircon, 4.5-5.3% monazite, and a small amount of Ni-Ta-minerals.

9. The extensive distribution of placer deposits in the stream valleys in North Manchuria forms a possible main source of rare metals. Monazite sands can definitely be extracted as by-products of gold mining. It is estimated that the productivity of monazite from gold placers may be taken as 50 to 100 times of the amount of gold produced.

PEGMATITIC DEPOSITS OF LIAOTUNG PENINSULA

10. The main rare metals resources of China occur chiefly in the South Manchuria peninsula provinces of Liaoning and Antung as pegmatite minerals in the pegmatites veins intruded into pre-Cambrian gneissic granites. Such rare metals bearing pegmatite veins are restricted to the igneous and metamorphic complex of the Sino-Korean Massive, probably of pre-Cambrian age. In this area three belts of distribution along the general trend of the peninsula in a north-south direction have been recognized namely, the west coast of the Gulf of Liaotung, the west coast of Liaotung Peninsula, and the east coast of that Peninsula. Among the ore minerals occurring in pegmatites, those containing uranium, thorium, zirconium, cerium, and other heavy rare elements are most abundant.

11. A. The West Coast of the Gulf of Liaotung

Both granite-pegmatite veins and secondary placer deposits were found along the west coast of the Gulf of Liaotung in several districts such as Chingchow, Chingsi, and Suichung (錦州錦西錦中). Euxenite, zircon, and allanite have been found in pegmatites at Tienchiao village of Chingchow (錦州天交村), and zircon and monazite in placer deposits nearby. In Tashan village of Chinsi (錦西塔山村) zircon and monazite have been found in placers, but only zircon in pegmatite veins. In Suichung district the pegmatite veins of Kaotai village (高台村) contain euxenite, zircon, and allanite; those of Chingsze village (金石村) contain betafite, zircon, and allanite; and in the placer deposits of the latter locality zircon and monazite have also been found. The economic importance of the rare metals deposits in this area has not been ascertained yet.

12. B. The West Coast of Liaotung Peninsula

The west coast of the peninsula, comprising districts of Liaoyang, Haicheng, Kaiping, and Shyongyao (遼陽海城蓋平東北) forms the main reserve of rare metals and the most productive belt in China. The occurrence of the minerals in pegmatite veins are of two types. The biotite-pegmatite veins bear euxenite and betafite with minor amounts of fergusonite, thorogummite, samarskite, zircon, allanite, etc, whereas in muscovite-pegmatite veins tantalite, columbite, beryl, monazite, etc, are predominant.

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13. One of the most important Japanese discoveries is the deposit in the vicinity of Haicheng district where numerous granite-pegmatite veins carry large quantities of euxenite, samarskite, and fergusonite. The veins, striking at northeast-southwest direction, have a length varying from 5 to 200 meters and averaging 20-30 meters, and a width of 5 meters. In the placer deposits of that locality, monazite, zircon, columbite, etc, and some uranium-minerals were also found. From 1944 to 1945 during the ten months period of mining by Japanese, 200 thousand tons of low-grade ores from two mines of the Haicheng district, the Tafangshen Mine (大房身) on the south and the Santaikou Mine (三台溝) on the north, and from which 40 thousand tons of concentrated ores were extracted with an average content of 8% UO₂. At the southern border of Haicheng district, in Pailotun (牌樓屯) and Simocheng (斯木城) the ore-bearing pegmatite veins occur partly in quartzites, crystalline limestones, magnesite rocks, phyllites, and mica-schists of Sinian Liaoho Series, and partly in Archaean gneissic granites, granites, diorites, and quartz-porphries. According to the lithological composition, texture, and kind of ore-minerals, the granite-pegmatite veins of that area have been subdivided into six types, details of which will not be discussed here.

14. In Lungchang Mining-hill (隆昌礦山), Paomikou (包米溝), Szaotaikou (小台溝), and Chisiangkou (吉羊山谷) of the Liaoyang district, beryl, columbite, allanite, etc, have been found in the muscovite-pegmatite veins intruded into pre-Sinian mica-schists. Numerous veins, striking in a NE-SW direction, have a length varying from 20 to 400 meters and a width of 4-5 meters, sometimes attaining 10 meters. Chemical analyses of the ores from this district were made by the Japanese.

15. West of Shyongyao and Kaiping districts, along the Fairy Isle Coast (仙人島海岸), the rich heavy sands containing 10.4% zircon, and 5.3% monazite were worked out entirely by the Japanese. Large quantities of low-grade beach sands are still left unworked along that coast.

16. C. The East Coast of Liaotung Peninsula

The coastal districts of eastern Liaoning and Antung provinces, such as Fengchen (鳳城), Antung (安東), Yeongyang (山東), Chungho (江河), Pulantien (普蘭店) have large quantities of placer deposits. In addition to the beach-type deposits, tantalite, columbite, and tungsten-ores were also found in granite-pegmatite veins intruded in the border zones between granites and pre-Cambrian Liaoho Series in Tungyuantu (通遼堡) of Fengchen district. The placer deposits of Mingyang village (明陽), Heitao village (黑島), Moershan village (木耳山村) of Antung and Chungho districts are high in zircon and monazite.

17. The heavy sands along the beaches east of Pulantien have a high content of zircon and monazite mixed with quartz, orthoclase, magnetite, titanite, garnet, hornblende, epidote, and biotite. The Japanese worked out a 600 ton rich pocket containing 4-5% zircon. But the average content of beach sands is about 0.5 to 1%.

PEGMATITIC DEPOSITS OF TACHINGSHAN RANGE, SUIYUAN PROVINCE

18. The occurrence of ores of rare metals in Suiyuan province is quite similar to those in the Liaotung region. In 1944 Japanese geologists first reported the occurrence of beryl, tantalite, columbite, and lepidolite with accessory zinnwaldite, monazite, and zircon in this area in the granite-pegmatite veins intruded into pre-Cambrian granites and gneissic granites. Minerals containing Be, Ta, Nb, Li, etc, belonging to the group of rare elements of light specific gravity, are characteristic of the pegmatites in this province. Lepidolite-pegmatites composed of lepidolite, feldspars, quartz, green

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tourmaline, topaz, etc form a distinct rock-type in this province in addition to the biotite-pegmatites and muscovite-pegmatites found in Liaotung Peninsula and in this area.

19. One pegmatitic zone, forming an east-west elongated belt about 400 km and 16 thousand sq km area along the southern foot of the Tachingshan Range, starts from Singho (央和口) passes through Chining (集寧), Lianchen (涼城), Pakou (吳口), Kuisui (烏蘇), Paotou (包頭), and ends at Wuyuan (五原). A second area of pegmatitic occurrence occurs to the north of the Range at Beiyun-ob of Pailingmiao (北雲?), Sikungchi (西公旗) and Chungkungchi (中公旗) and to the northwestern corner of the province in the Samotiensmo-region (薩盟員斯默).

20. In Yushukou of Sinho district (央和榆樹溝), southern part of the province, muscovite-pegmatite veins contain large amounts of beryl and columbite. In Kuantsun of the Chining district (集寧官木村) muscovite-pegmatite veins intruded in gneissic granites contain large amounts of beryl associated with titanite, magnetite, hematite, and fluorite. In Sanchakou (三岔口) and Hochiakou (侯家溝) of that district, large amounts of beryl as well as gadolinite, fergusonite, tourmaline and small amounts of ilmenorutile were also found. In Maotouching of Kuisui (烏蘇毛頭溝) muscovite-pegmatite veins contain large amounts of beryl and columbite and small amounts of monazite associated with tourmaline, topaz, garnet, etc. From that locality three tons of beryl and 300 kilograms of columbite were worked out by natives during one and one-half years from 1944 to 1945.

21. The main resources of rare metals of this province occur in an area west of Paotou district and on the northern slope of the range. The muscovite-pegmatite veins of Sikungchi (五公旗) containing beryl, columbite and small amounts of euxenite are worthy of a large-scale exploration. The biotite-pegmatite veins of Chungtan (中溫產) contain allanite and zircon associated with feldspar and quartz. The veins intruded in hornblende-gneisses and biotite-augen-gneisses are numerous and widely distributed. The reserve of allanite of 40 outcrops surveyed in that location is estimated at 50-70 tons. It is believed that large reserves of zircon might be found in the placer deposits by detailed investigation. In Samotiensmo region large quantities of beryl, columbite, and tantalite associated with muscovite, tourmaline, cassiterite, zinnwaldite, as well as small amounts of ilmenorutile, xenotime, and some uranium-minerals were found in lepidolite-pegmatite veins intruded into biotite gneissic granites and crystalline limestones. The beryl crystals are usually a few centimeters in diameter, some of them may attain one meter in diameter, generally weigh several to one hundred pounds. Columbite and tantalite crystals are usually short and stout, about one to three cm in length, sometimes massive with exceptionally large crystals weighing four kilos. From 1944 to 1945, 225 tons of muscovite, three tons of beryl, 130 tons of lepidolite and four tons of columbite and tantalite were extracted by Japanese in this area.

22. Besides the above stated localities, uranium ores were also reported to occur in Shamentien of Wuyuan district (五原沙門元), Maotouchen of Hohar district (呼和浩特頭頭), and Yusien of Chining (集寧魚心).

23. Cerite, columbite, tantalite associated with yttrrocerite fluorite were found to occur between limestone and granite in the contact-zones of Beiyun-ob of metasomatic iron ore deposits in Pailingmiao. The iron ore of that locality containing traces of cerite are particularly suitable for aircraft steel uses.

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24. The pegmatite veins in Huanghakeeting (黃花格山頭), Tsungshenkou (通屬口), Hsumakou (徐馬溝) of Taoling district (陶林木) have long been known to produce amethyst beryl, and topaz. North of Kuyang (固陽) natives worked out two thousand kilos of rock-crystal and a large quantity of muscovite from pegmatite veins.

25. In Langyuan (涼源), Wutai (五台), and Hungyuan (恒源) of northern Shensi beryl crystals have been found in some pegmatite veins. On account of the extensive distribution of Archaean granites and gneisses and intruded pegmatite veins, some rare metals deposits might possibly be found with the effort of detail investigation in the border region between Suiyuan, Charhar, Shansi, and Hopei provinces.

PEGMATITIC AND HYDROTHERMAL VEINS OF THE NANLING RANGE

26. The Nanling Range has long been known to have the main reserve of tin and tungsten of China. Some minerals of rare metals which were worked out in association with tin and tungsten ores in the past were considered as useless gangue-minerals by native miners. With the modern development in the uses of rare metals, the discoveries of such deposits have been reported at a few scattered prospectings in Kiangsi, Hunan, and Kwangsi provinces.

27. In Tungmaoling, Kansien, Kiangsi (贛縣金鈎山) granite-pegmatite veins intruded into Mesozoic granites contain cassiterite, tourmaline, and beryl. Those in Sihwashan of Tayu (大庾西華山) contain beryl, cassiterite, scheelite, topaz, fluorite, wolframite, lepidolite, etc. The mineralogical association of cassiterite and beryl was also found in Piaotan (漂塘) of that district. In Hwamei of Sinkou district (興國金口), Tachishan of Chianan (虔南大吉山), Shaping of Yutu (雩都上平), and Shangyou (上猶) pegmatite veins are also well developed.

28. In the same province the alluvial tin-placers occurring at Chitu, Nankon (寧康赤土) and Yangmaitze, Chungyi (崇義楊眉子) contain monazite in some amount. The wolframite-placer deposits of Yangmaitze, Chungyi and Shongping, Yutu were suspected to contain uranium minerals.

29. In Shahuken, Ruchen (汝城沙湖梗), southern Hunan, the association of cassiterite, beryl, and lepidolite was reported to occur in pegmatite veins. In the tin and tungsten mining area of Fuchuan, Hosien, and Chungshan (富川賀縣金鐘山) the possibilities of rare metals deposits discoveries look very bright. An occurrence of uranium-ores was reported in Huangchianping of Chungshan (惶山黃尖平) where a small amount of pitchblende and secondary uranium-minerals as gummite, tobernite, uranophane, and autunite occur at the intersection of a pegmatite vein and another aplite vein.

POSSIBLE OCCURRENCES

30. On account of similarity in the geological setup between Shantung Peninsula and Liaotung Peninsula, it is possible that some deposits may be found in Shantung province as the continuation of the three rare-metals bearing pegmatite belts of Liaotung Peninsula. The extensive occurrence of Archaean granites with pegmatite veins in the area north of the Archaean Taishan Complex, starting from Faichen (肥城), passing through Laiyu (萊蕪), Lintzy (臨淄), Changyi (昌邑), Tien (棗縣), Lungkou (龍口), Punglai (蓬萊), to Chefoo (大連), has possibilities of future findings. Along the coast of Tsingtao (青島), in the same province, the beach sands were reported to contain small amounts of monazite, allanite, and zircon.

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31. In the Kungshan-region (貢山), western Yunnan, columbite, beryl, and spondumene were found in numerous pegmatite veins intruded in Mesozoic granites. The same association of beryl and columbite was also found in cassiterite veins in Kwehchew (箇舊), southern Yunnan.

32. In Yangshan (木易山) in the southern vicinity of Nanking, a barite vein about 100 meters long and five meters wide, intruded into Cretaceous volcanic rocks, was found to contain a small amount of pitchblende associated with limonite.

33. In the western part of the Tienhsing Range, Sinkiang (新疆天山), the occurrence of uranium-minerals is also said to have been tested by the Soviets with electroscopes.

34. Alluvial sands in Yiho-valley, Yisien, Hopei (河北易縣易河) containing traces of uranium-minerals have been found. However, the exact state of occurrence at the above localities has not yet been evaluated.

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